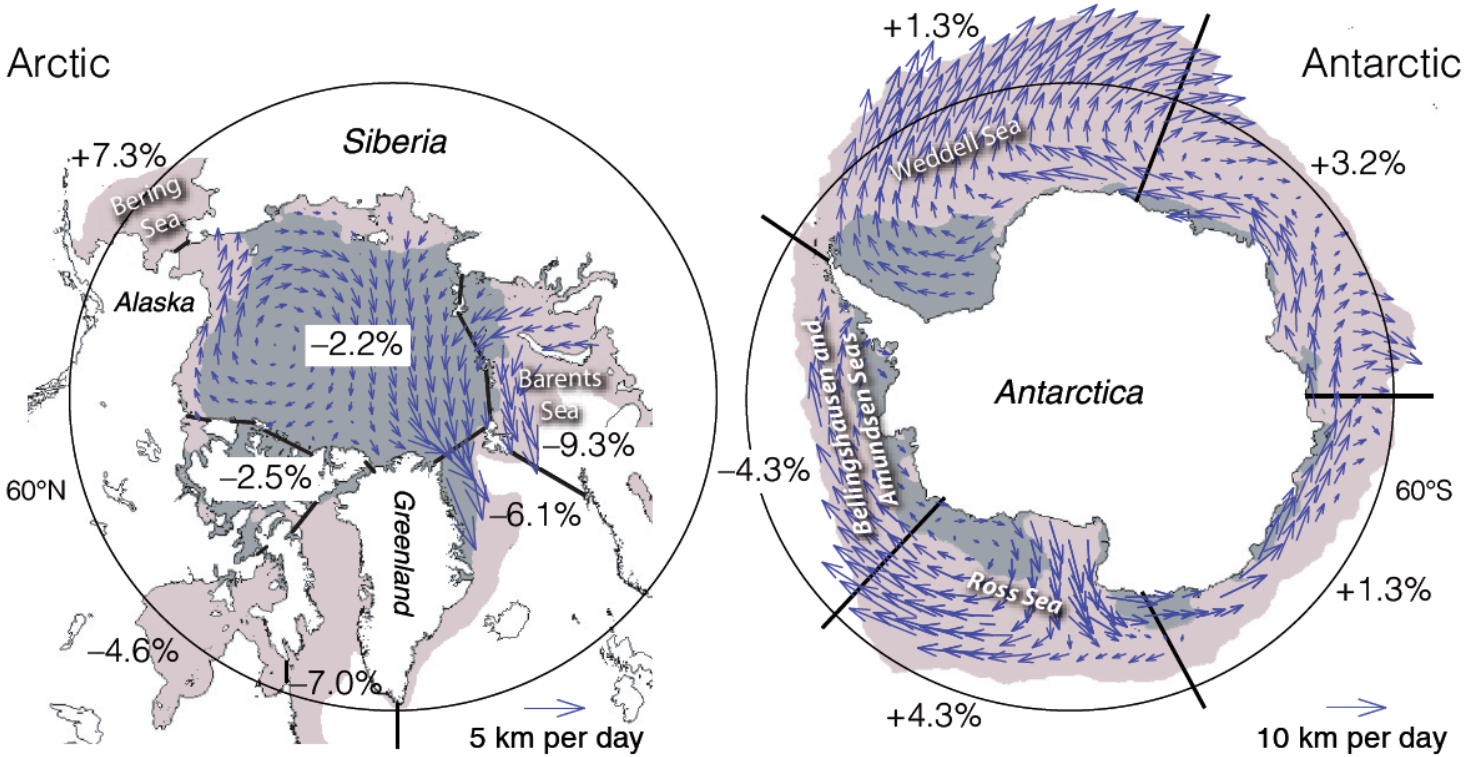
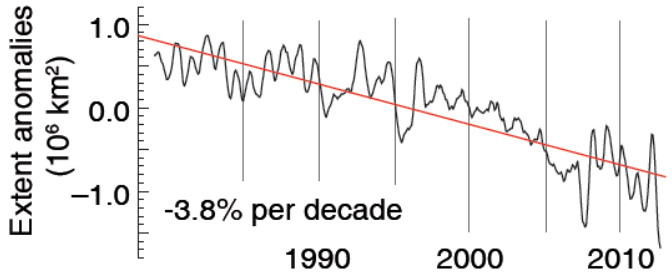
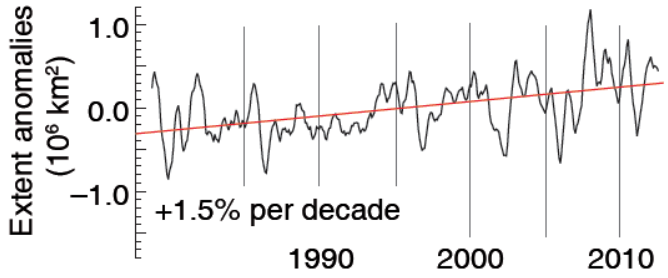
Use of observational data sets: Arctic and Antarctic sea ice

- Current
  - Sampling, continuity, and calibration
- Future
  - CMIP6 model evaluation/assessment
  - Development? Processes?

Regional trends in ice coverage and mean ice motion (33-year)







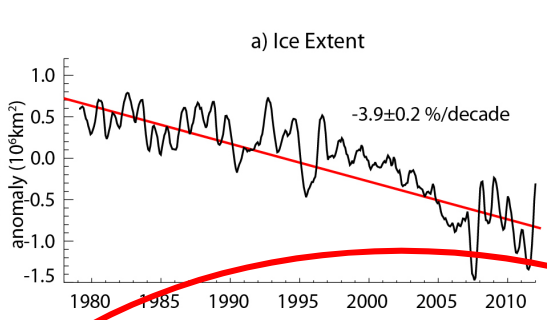
Summary of Arctic sea ice changes in AR5-WG1 Chapter 4: Cryosphere

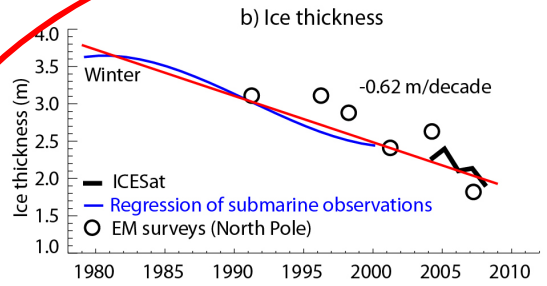
5 Key Indicators

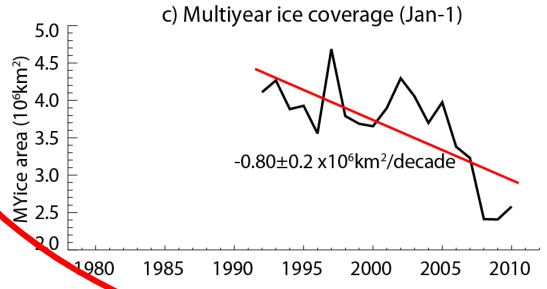
Extent

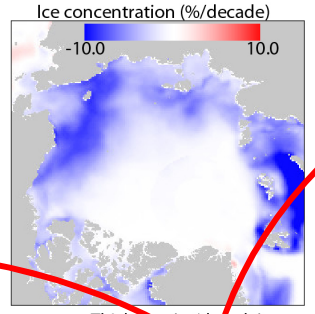
Thickness

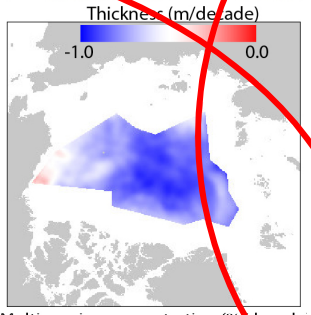
Multiyear ice

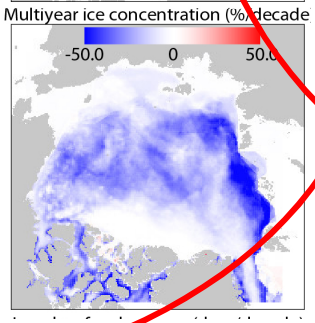




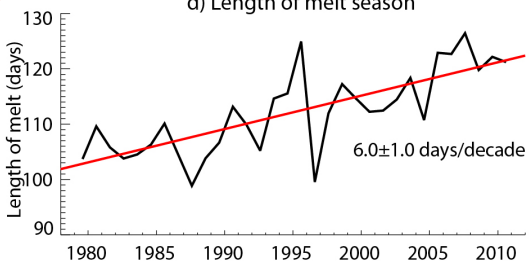


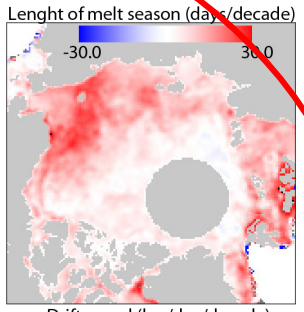


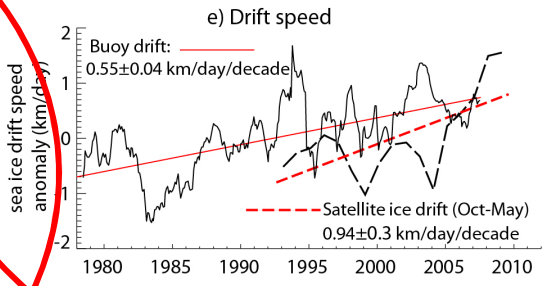


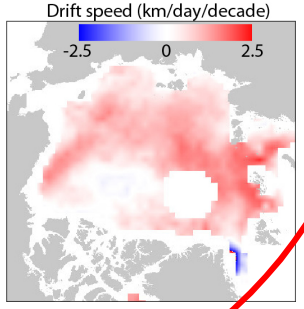


Length of melt season





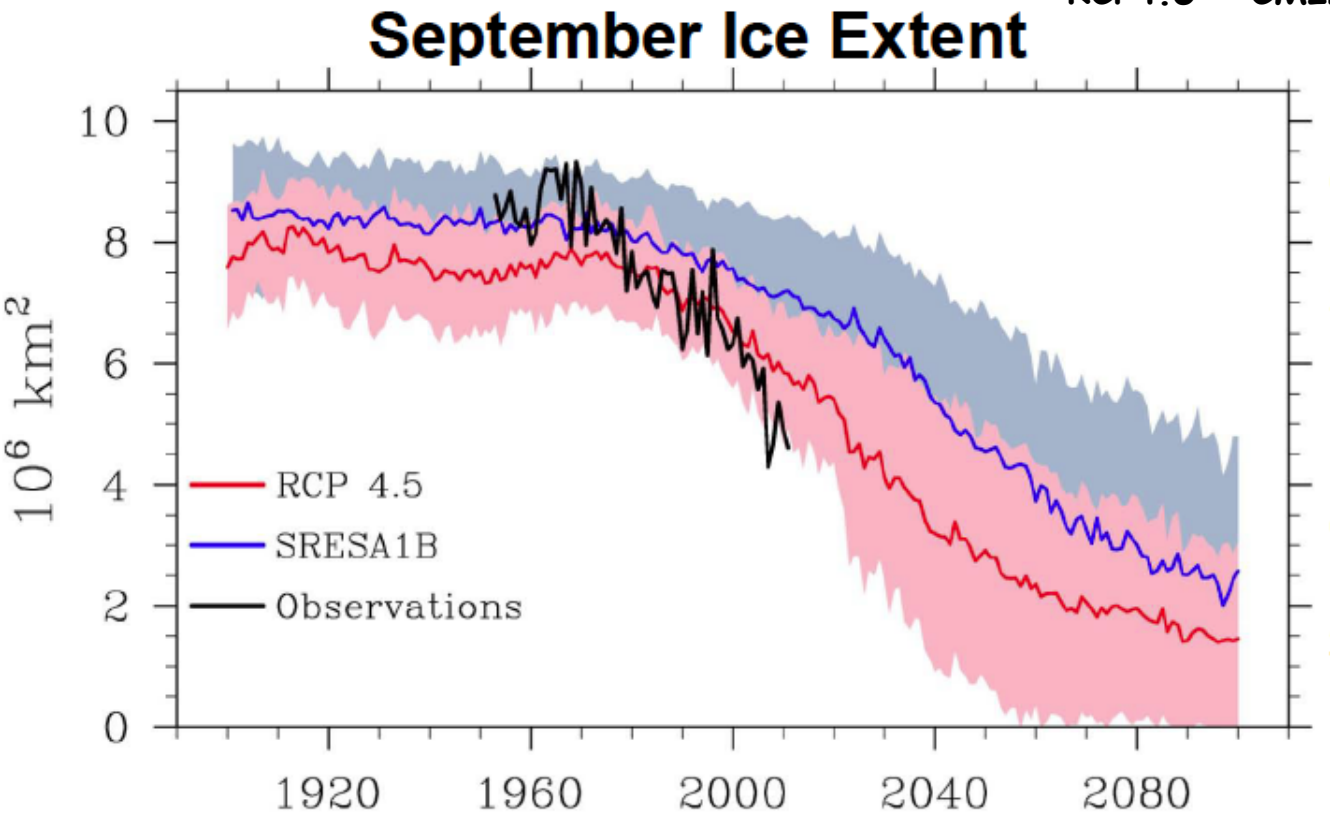




Drift Speed/Circulation

Arctic summer ice extent: Comparison with models

RCP4.5 = CMIP5 SRESA1B = CMIP3

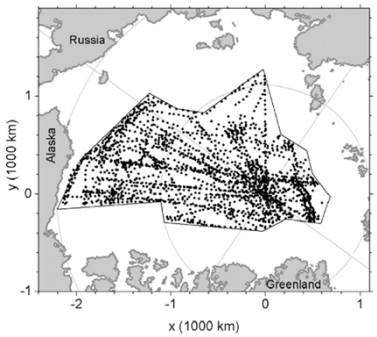


1953-2011
Observed = -9.0+0.60%/dec
RCP4.5 = -4.6+0.30%/dec
SRESA1B= -4.2+0.25%/dec

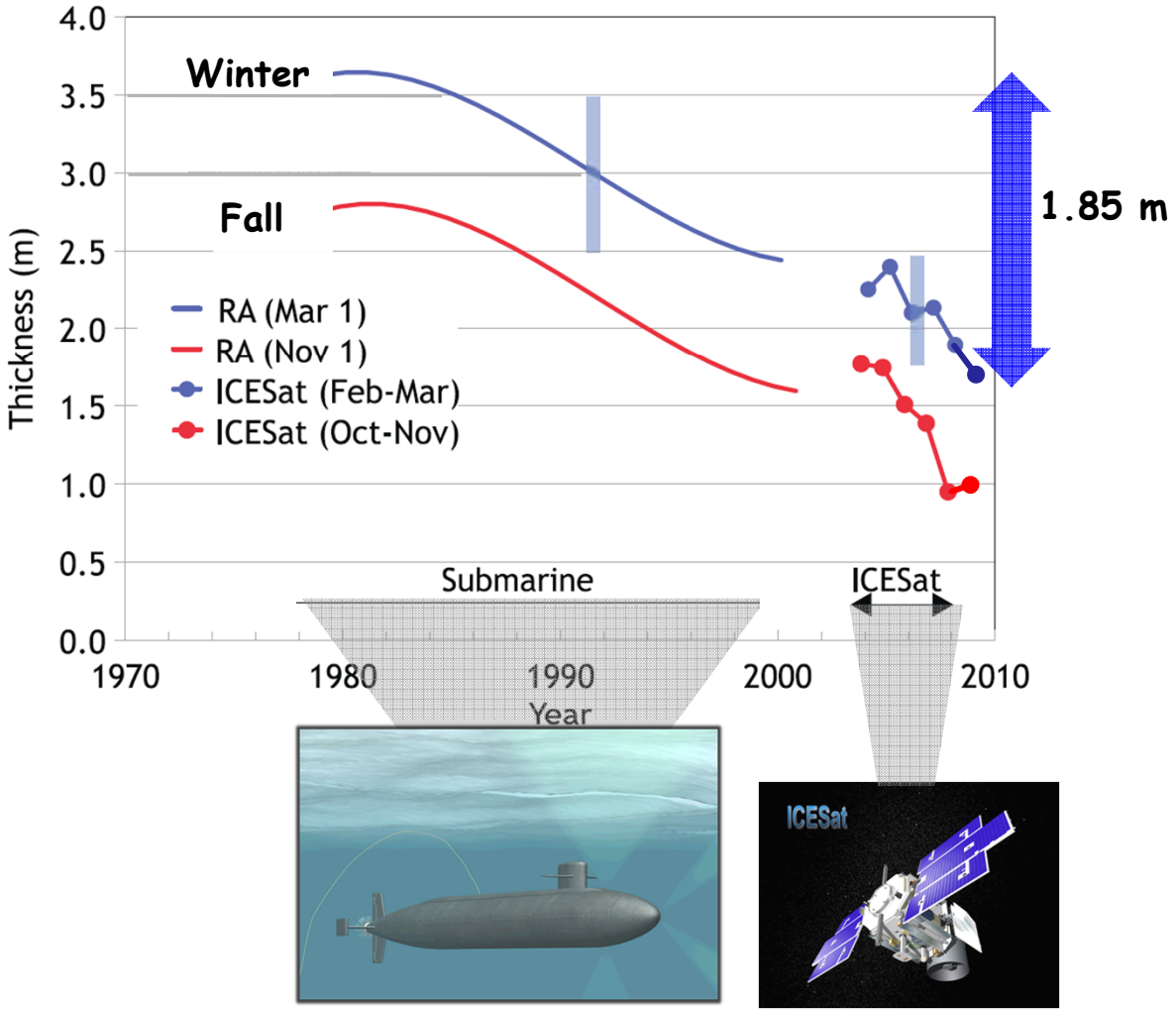
1979-2011
Observed = -13.0+1.49%/dec
RCP4.5 = -8.2+0.37%/dec
SRESA1B= -6.6+0.42%/dec

Stroeve and Barrett, 2012

Decline in sea ice thickness from submarine and ICESat records: 1978 - 2009



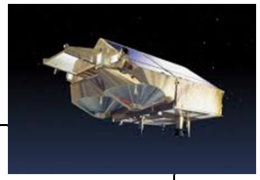
Note: Submarine estimates based on regression of available ice draft from US Navy submarines



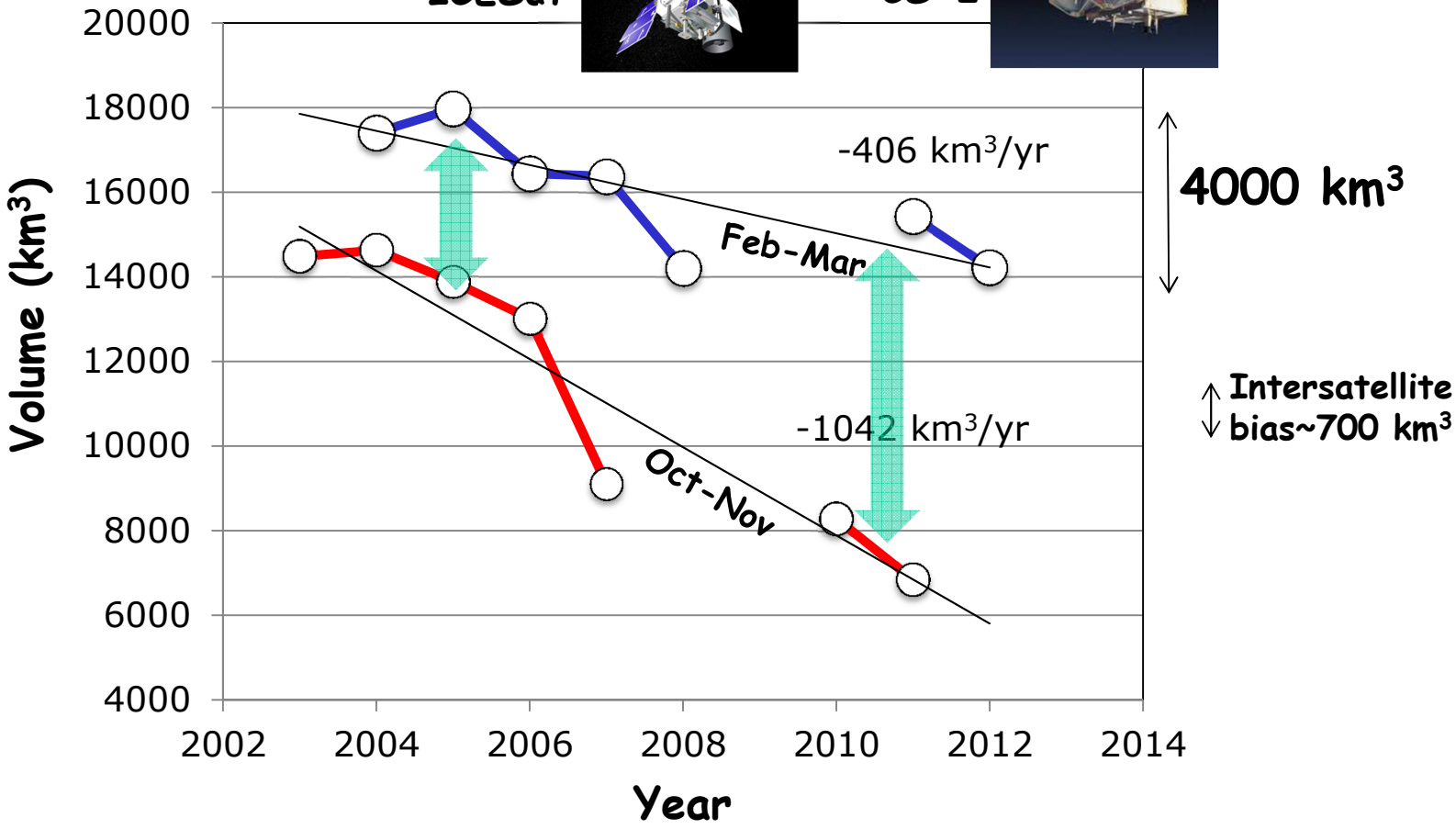
(Kwok and Rothrock, 2009)

ICESat/CryoSat-2
Arctic basin ice volume

ICESat

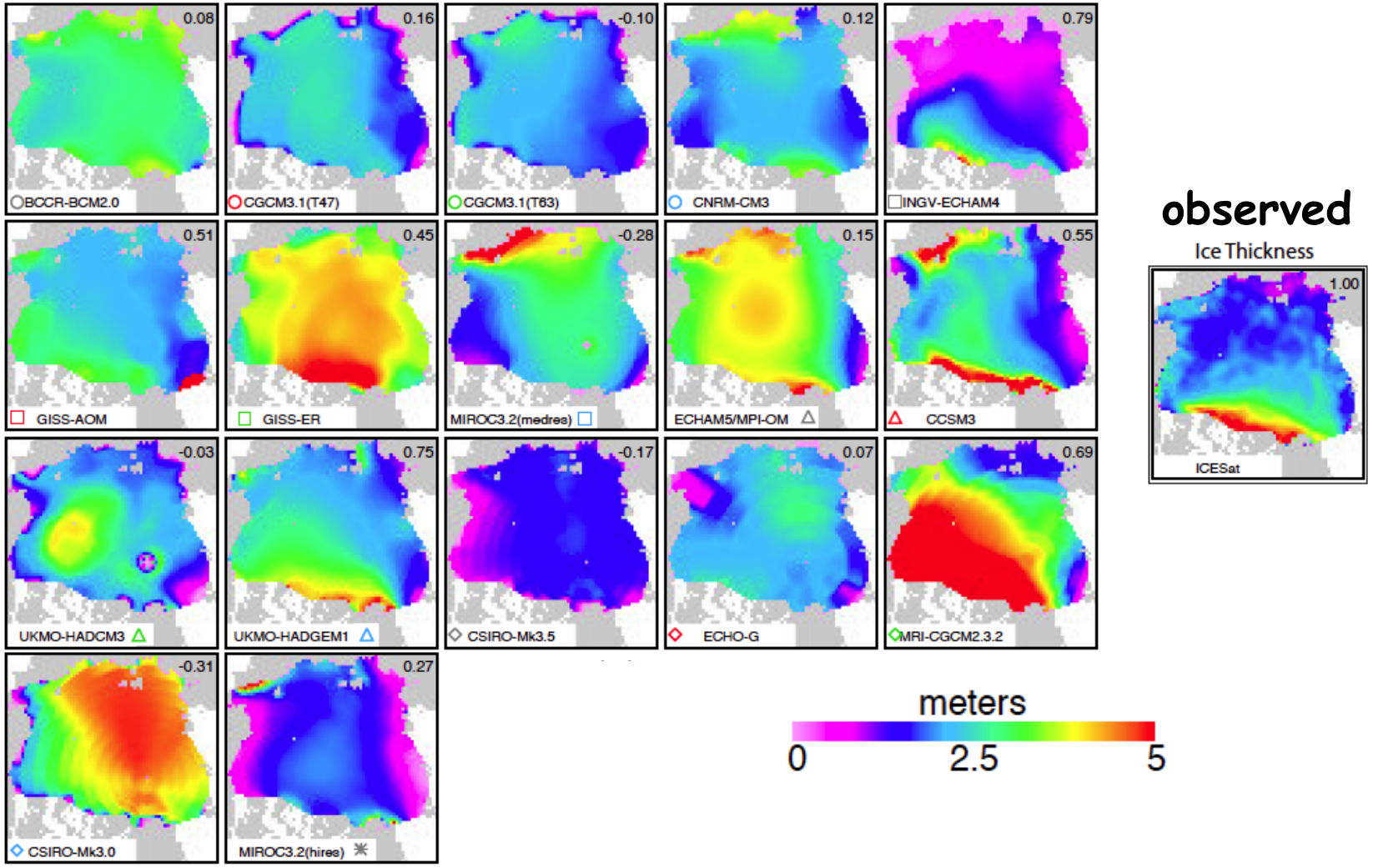


CS-2

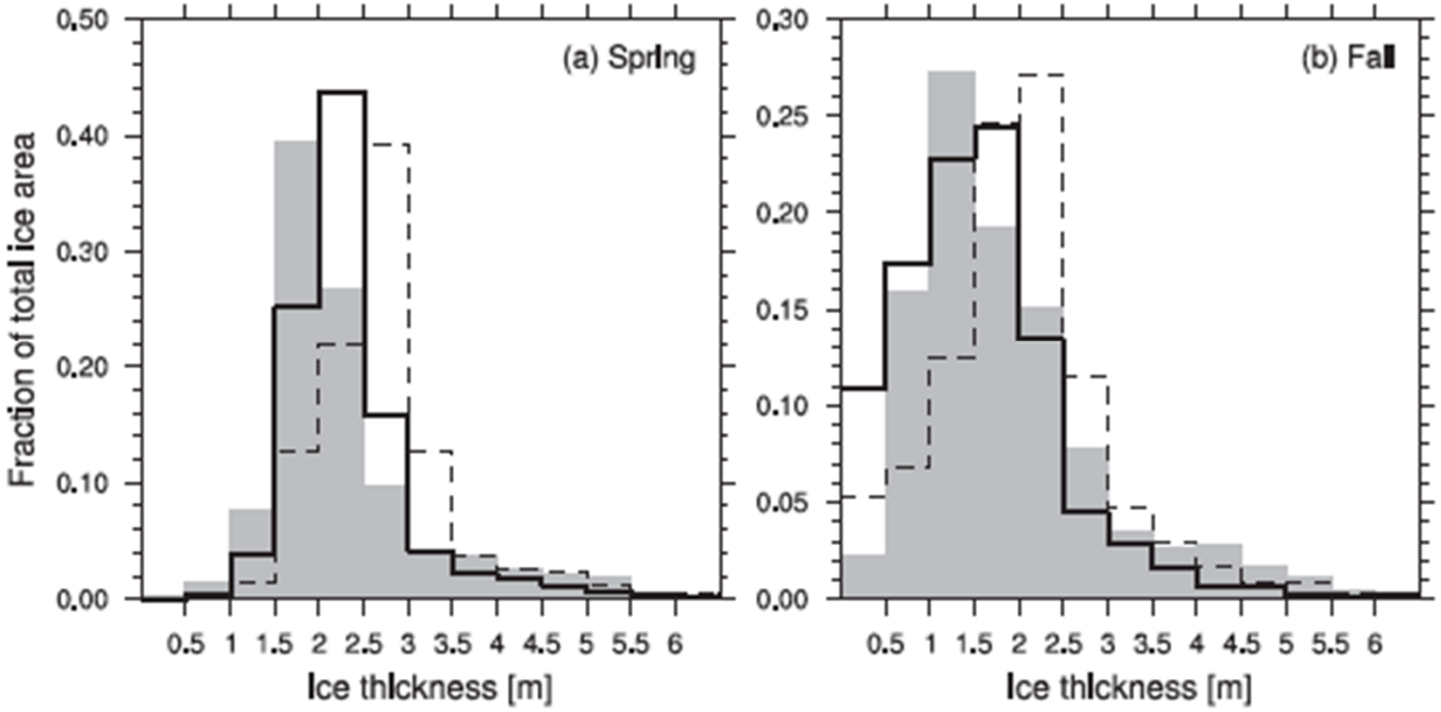


Sea ice thickness/volume

Ice thickness – spatial distribution
Comparisons with models



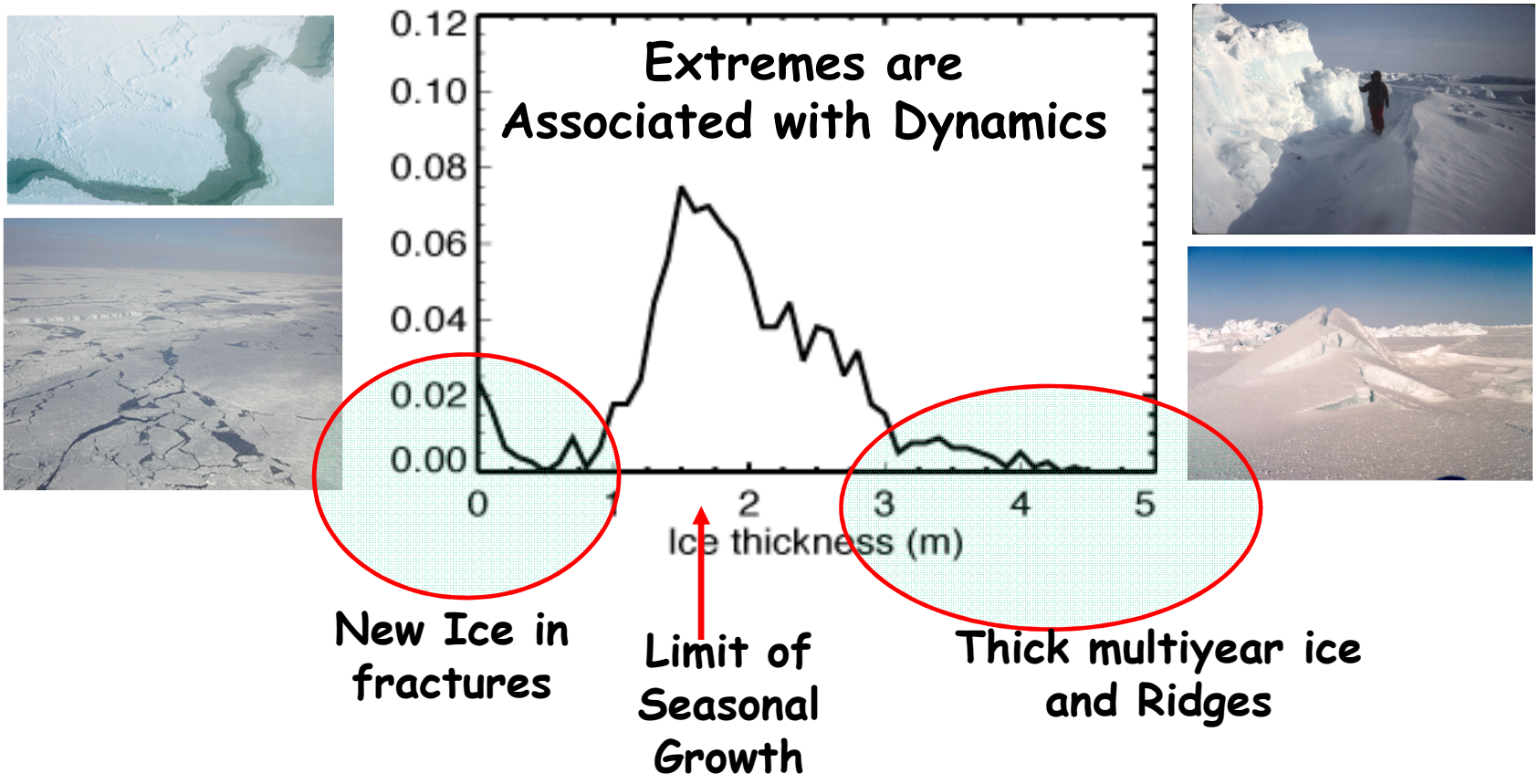
Thickness distribution (CCSM4 vs ICESat)



Jahn et al.,2012

Ice thickness distribution

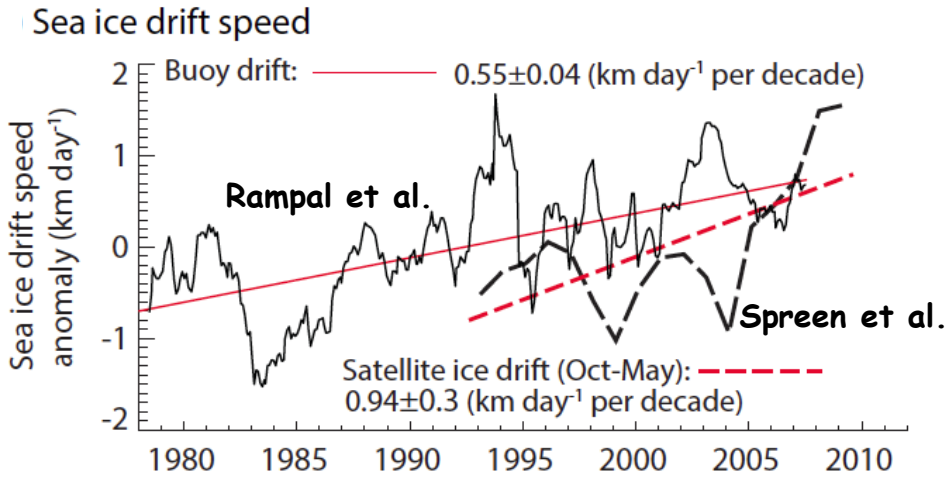
Sample thickness distribution: ~100 km transect

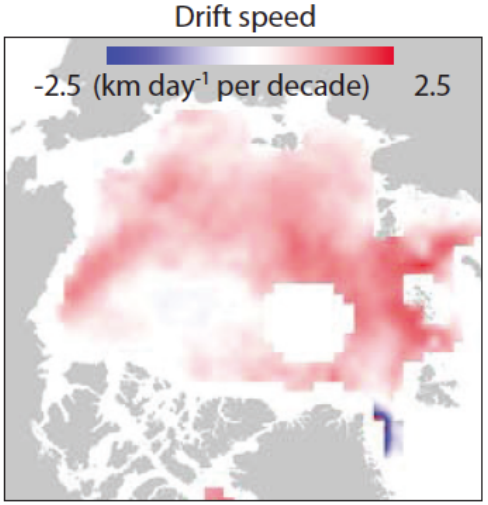


Thickness distribution:
Variability due to Thermodynamics and Dynamics

Ice Drift:
Large Scale

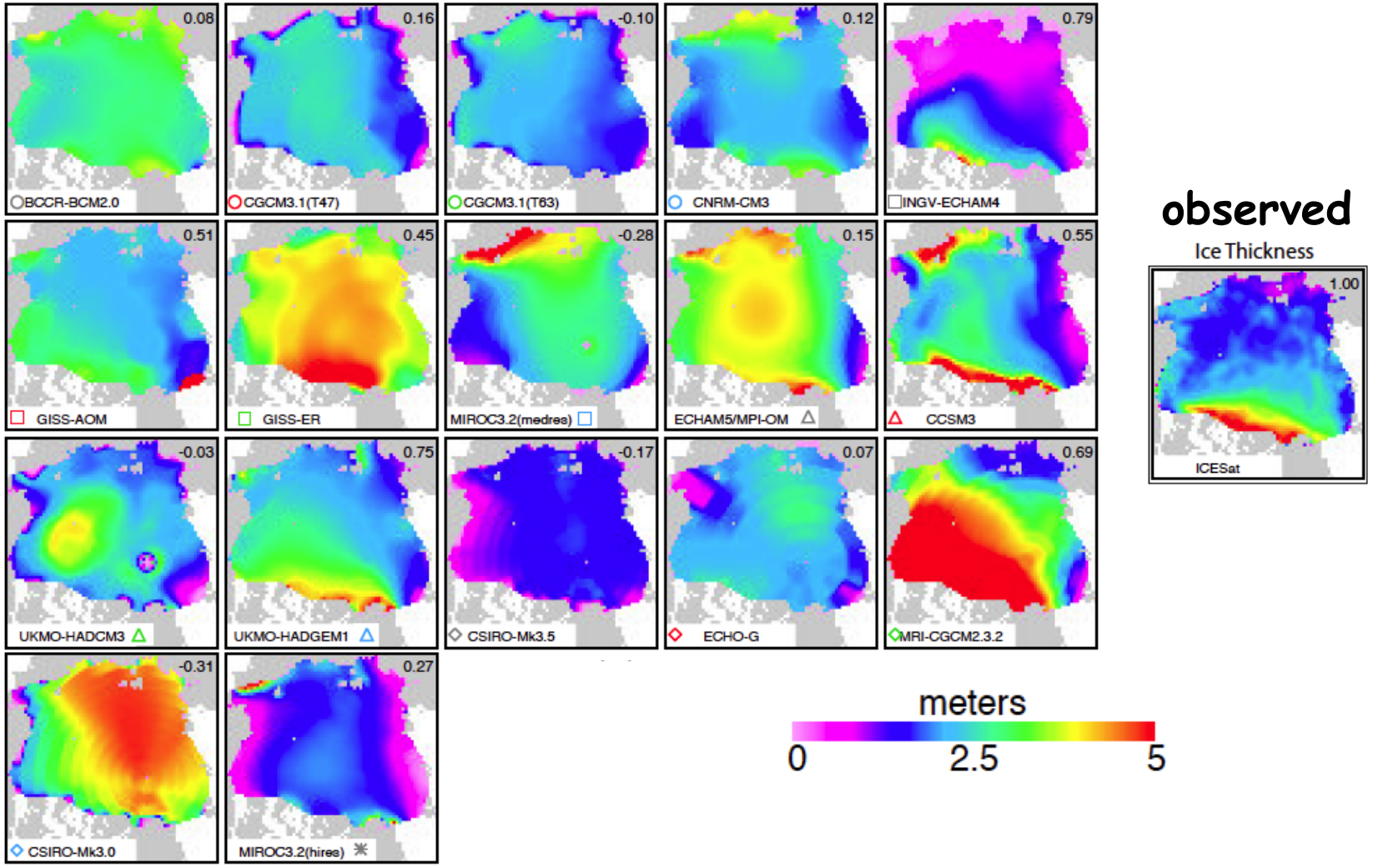
IPCC-AR5
Executive Summary Statement:
Ice Drift



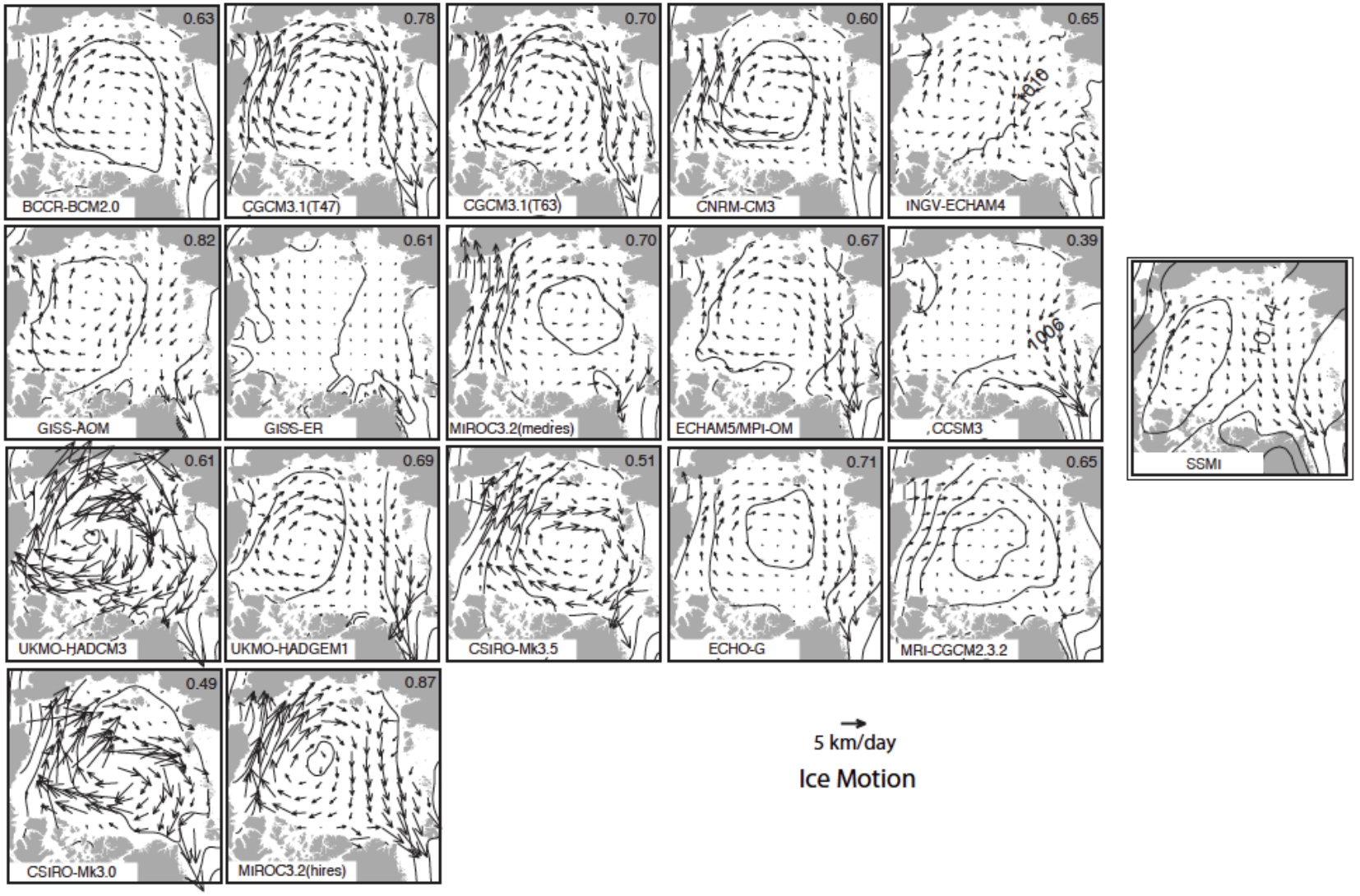


The average winter sea ice thickness within the Arctic Basin decreased between 1980 and 2008 (high confidence). The average decrease was likely between 1.3 and 2.3 m. High confidence in this assessment is based on observations from multiple sources: submarine, electro-magnetic (EM) probes, and satellite altimetry, and is consistent with the decline in multi-year and perennial ice extent. Satellite measurements made in the period 2010–2012 show a decrease in sea ice volume compared to those made over the period 2003–2008 (medium confidence). There is high confidence that in the Arctic, where the sea ice thickness has decreased, the sea ice drift speed has increased.

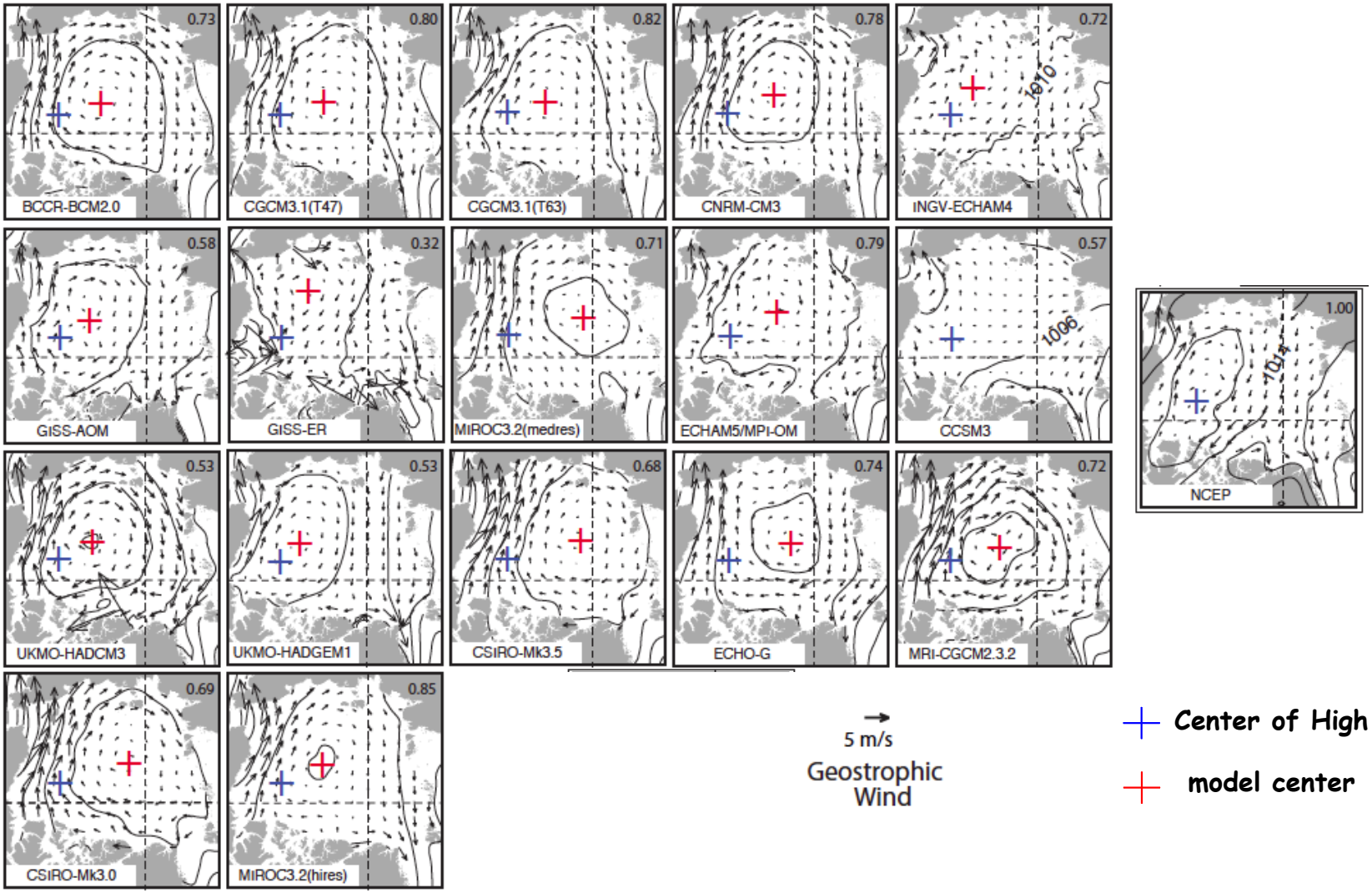
Ice thickness – spatial distribution
Comparisons with models



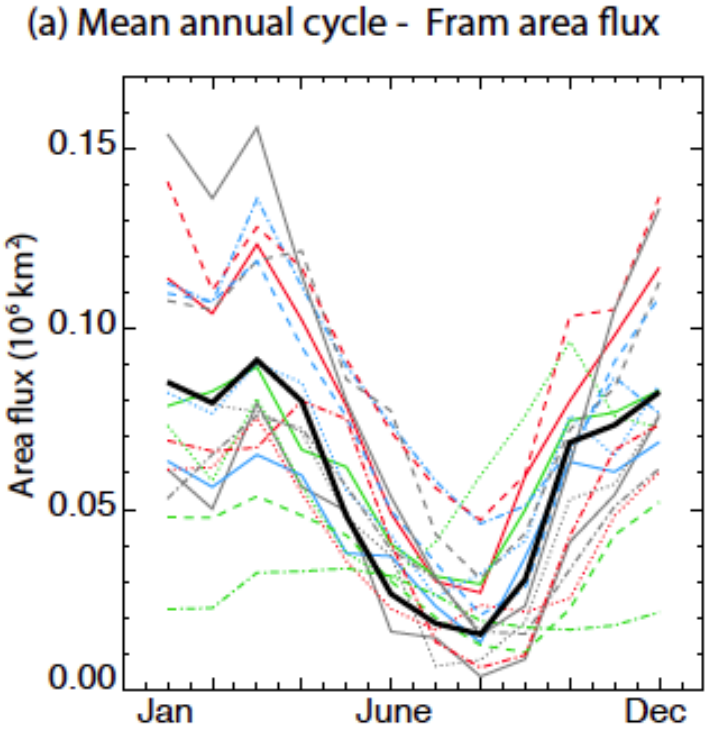
Large scale circulation/export

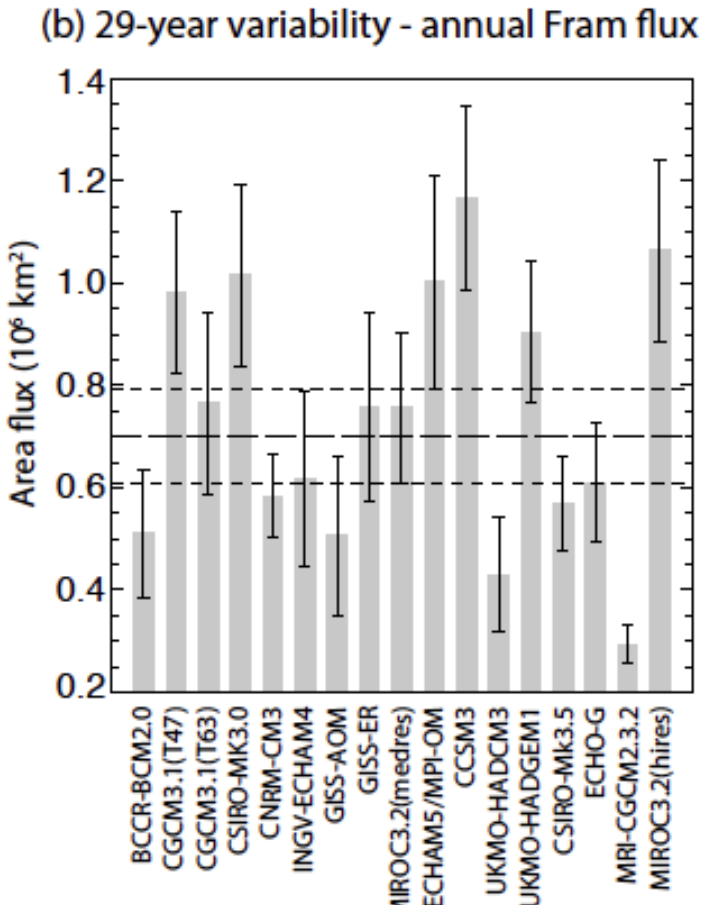


Model geostrophic winds



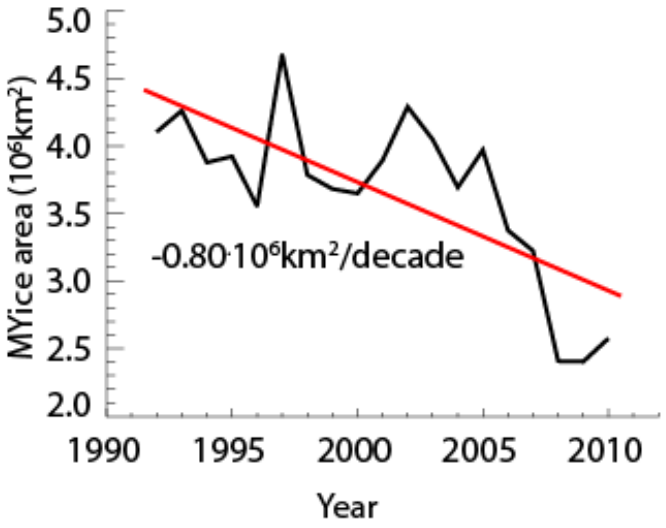
Ice Area/Volume Export – variability (mass/area balance)



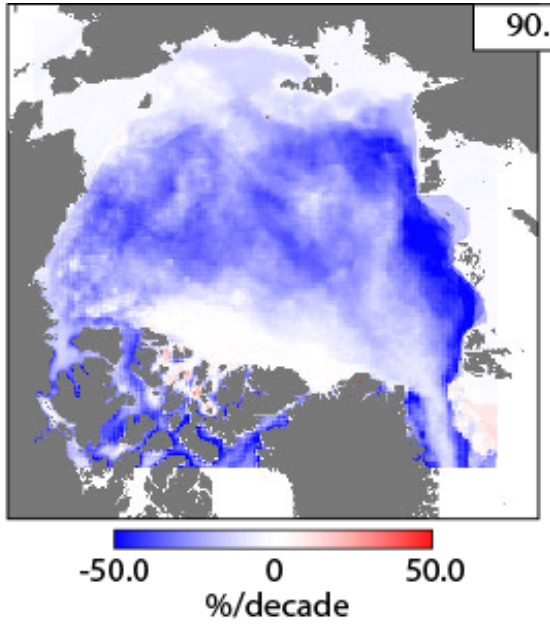


Satellite Ice Drift and MY ice coverage 1992-2010

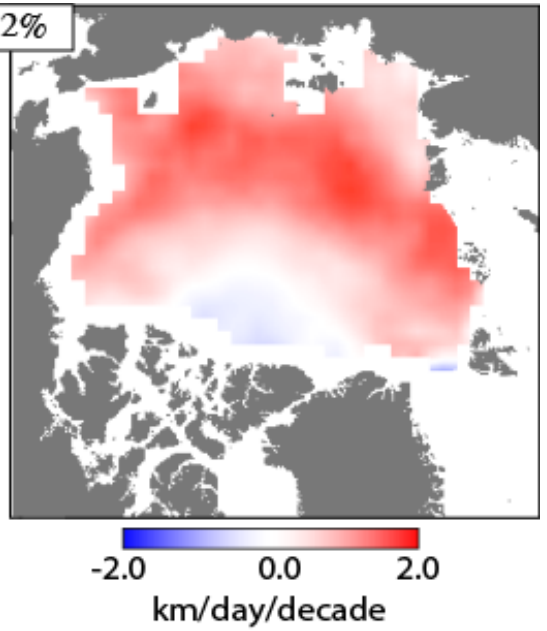
MY ice coverage trend



MY ice coverage trend

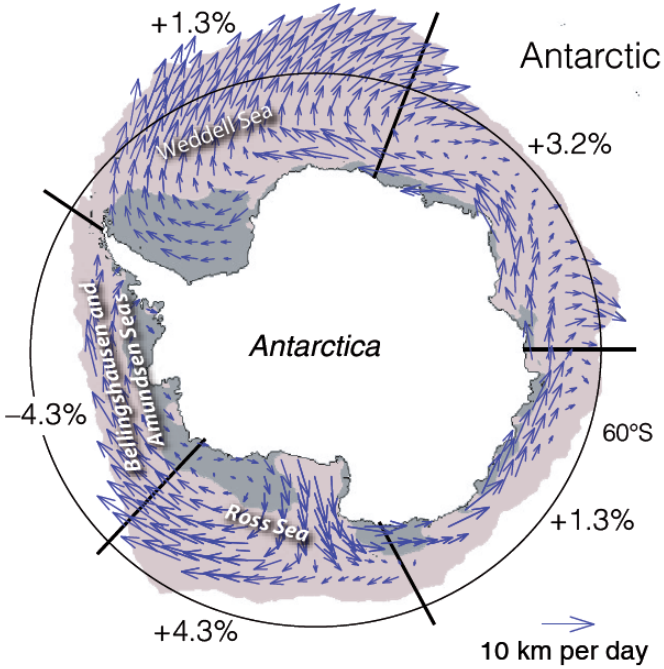


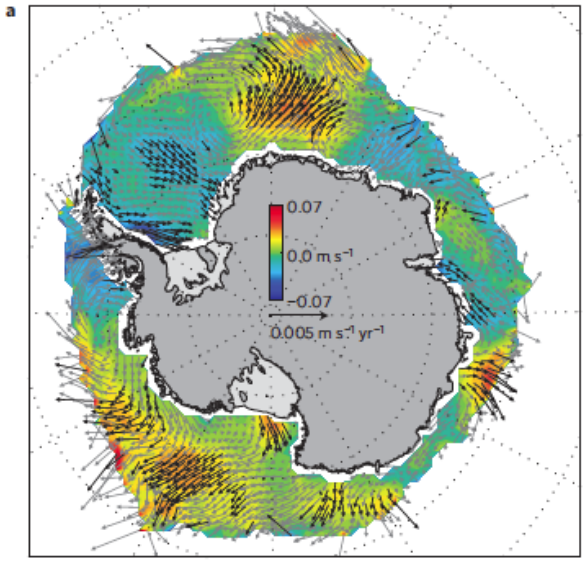
Trend in drift speed

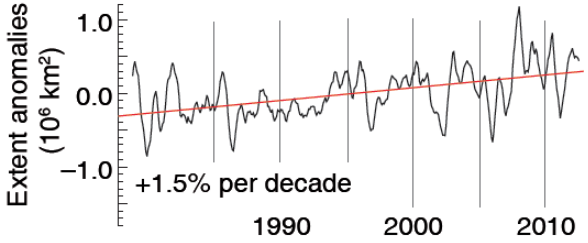


Kwok et al., 2013

Antarctic sea ice coverage/drift speed







Some of the wind-driven trends reported were noted in AR-5 1992-2010

Holland and Kwok, 2013

Summary (1)

- Modelers are actively using the available products for model evaluation
  - Available gridded data sets
  - Variables examined:
    - Coverage, age, thickness, volume, melt season, motion

- Limitations
  - Still limited to ~30 years of data

Summary (2)

Observational data sets - Current

- (Arctic)
  - Ice Thickness/Volume
    - Mix of satellite, submarine, in-situ obs
  - Coarse Ice Drift (32 years)
  - Length of melt season (Onset to freeze-up) (32 years)
  - Ice Age (multiyear, seasonal ice)

- (Antarctic)
  - Ice Drift (32 years)
  - Length of melt season (32 years)

Summary (3)

Future

- (Arctic)
  - Ice Thickness/Volume (monthly)
    - Better satellite obs (CryoSat-2, ICESat-2)
  - Coarse Ice Drift (continuing time series)
  - Fine scale ice drift (ice deformation)
  - Length of melt season (continuing)
  - Melt pond coverage

- (Antarctic)
  - Coarse Ice Drift (continuing)
  - Length of melt season (continuing)
  - Ice thickness (???)

Summary (4)

CMIP6 sampling (Arctic/Antarctic) needs

- Ice Thickness/Volume (monthly)
- Coarse Ice Drift (monthly – daily?)
- Length of melt from ice/snow surface temperatures (surface daily)
- Multiyear ice coverage (that's more difficult)